# Progress Report

DOE award number: DE-SC0007341

Name of the recipient: University of Virginia

Project title: Hybrid Network Traffic Engineering System

Principal investigator: Malathi Veeraraghavan

Date of report: May 1, 2012

Period covered by the report: Jan. 15, 2012 - Apr. 14, 2012

**Comparison of the actual accomplishments with the goals and objectives established for the period and reasons why the established goals were not met.**

The goals for the first quarter in the timeline defined in the proposal were to run experiments on ESnet and ANI testbed to capture control-connection packets for file transfer applications, and to design new online flow detection algorithms. Both these activities were planned for the first proposed work item, which is to design new online flow detection algorithms because the Hybrid Network Traffic Engineering System (HNTES) developed in the first project used offline mechanisms. Three approaches were identified in the proposal for online schemes, port mirroring, payload based scheme and NetFlow analysis scheme. The first work item to capture control-connection packets for file transfer applications was intended to study the feasibility of the payload based scheme. Our findings are that control messages in GridFTP are encrypted and therefore, at least for GridFTP, such a payload based scheme for online detection is not feasible. Toward the second work item, hybrid offline-online algorithms have been designed, and two new offline algorithms are under development. Further details are provided below.

**A discussion of what was accomplished under these goals during this reporting period, including major activities, significant results, major findings or conclusions, key outcomes or other achievements. This section should not contain any proprietary data or other information not subject to public release. If such information is important to reporting progress, do not include the information, but include a note in the report advising the reader to contact the Principal Investigator or the Project Director for further information.**

## 1 Activities

- Offline Flow Analysis Tool development: In the algorithm designed in HNTES I (2009 initiated project), referred to as "Algorithm I," alpha flows are defined to be flows in which the number of bytes sent exceeds 1 GB in any time period less than or equal to 1 min. Based on feedback received from the DOE program manager and other participants at the Jan. 2012 DOE project review meeting at BNL, two new algorithms (Algorithms II and III) were designed and implemented in this quarter and are currently under evaluation. In Algorithm II, first flow rate is computed for each flow report by dividing the reported bytes by the flow duration. If this flow rate exceeds 133 Mbps (1 GB/60 sec), then the size (number of bytes in the flow report) is compared against a size threshold of 900 MB. Thus, flows that exceed these rate and size thresholds in any time duration within their lifetimes are classified as alpha flows. In Algorithm III, aggregate flow size and flow rate thresholds across multiple parallel TCP streams (which are

often used in GridFTP and other high-speed file transfer applications) are used to identify alpha flows.

- NetFlow data analysis: At the DOE PI meeting at BNL in Jan. 2012, our program manager recommended that we investigate the potential value of HNTES for other service providers, in addition to ESnet. Therefore, we obtained NetFlow data from Internet2 and are running our alpha flow identification code on this data. Unlike with ESnet data, Internet2's NetFlow reports have flow durations that are longer than 1 min. Therefore, Algorithm I cannot be readily applied to this data, while Algorithm II can be used to analyze Internet2's NetFlow reports. A dataset containing NetFlow reports from one Internet2 router (Chicago) for 105 days, i.e., from October 2011 to January 2012, except for a missing period of 18 days, was obtained and analyzed.

- ANI testbed experiments: OWAMP (an Internet2 implementation of One-Way Active Measurement Protocol) software was downloaded from Internet2's repository to two hosts on the ANI testbed. The software was successfully installed and configured. Experiments were conducted to test one-way delay between the two hosts. In order to obtain valid measurements, NTP had to be configured to reference multiple NTP servers. The purpose of this activity was to gain an understanding of OWAMP, following which the preliminary work described in the proposal, to test the effect of alpha flows on delay-sensitive applications, will be extended.

- OpenFlow: In this quarter, we undertook training to learn how OpenFlow works. Papers and tutorials on OpenFlow were studied. Required software for the OpenFlow tutorial were downloaded and installed. Our next step is to undertake experiments on the OpenFlow switches in the ANI testbed. Our primary goal is to determine if the time to configure firewall filters (needed for HNTES) is smaller than on Juniper routers.

## 2 Findings

- Offline Flow Analysis Tool Development and NetFlow data analysis: Our findings from executing Algorithm II code on Internet2 NetFlow data for a period of 105 days are as follows. There were 1114 /21 prefix α-flows. While the longest per-day prefix flow duration was more than 8 hours, most prefix flows were shorter than 2 mins. The prefix flow with the maximum number of occurrences appeared every day in the observed 105-day period, while more than 21% of the prefix alpha flows occurred more than 10 days within that period.

- ANI testbed: The OWAMP testing showed approximately the same one-way delay measurements between newy-diskpt-1 and bnl-diskpt-1. The median one-way delay between the two hosts (either direction) is 1.1 ms, and the jitter was less than 0.1 ms (the measurement depends on other traffic on the network). These simple tests were run just to get familiar with OWAMP. New tests are planned to test the impact of alpha flows (large-sized, high-rate GridFTP flows) on OWAMP delays.

- Online alpha flow identification algorithms: Based on feedback from ESnet, the third approach of running for online detection, which is to export NetFlow data on a "real-time" basis for external analysis, was deemed infeasible with the deployed Juniper routers. Even with Juniper's expensive cards (which ESnet has not deployed), 15 seconds is the shortest timeout interval that

can be configured (for NetFlow exporter to send data to an external NetFlow collector). Juniper routers without these expensive service PICs/DPCs have a minimum configuration time of 60 sec. With Alcatel routers, the minimum duration is 10 seconds. Since a majority of alpha flows are short-lived, it becomes infeasible to analyze NetFlow data on a real-time basis for online alpha flow identification. At this point, all three approaches for online alpha flow identification seem impractical due to technology constraints and the short-duration characteristics of alpha flows, but we are currently evaluating whether the offline scheme performance is sufficient thus negating the need for online detection mechanisms. Results are being documented for a journal submission.

**Cost Status. Show approved budget by budget period and actual costs incurred. If cost sharing is required break out by DOE share, recipient share, and total costs.**

Please see attached file.

**Schedule Status. List milestones, anticipated completion dates and actual completion dates. If you submitted a project management plan with your application, you must use this plan to report schedule and budget variance. You may use your own project management system to provide this information.**

As per the proposal, which is available on the project web site, the milestone for this quarter is as follows:

| | |
|---|---|
| July 14, 2012 | • Design, prototyping and testing of new algorithms for HNTES 3.0 |

**Next quarter deliverables:**

By the end of the next quarter, July 15th, 2012, the following deliverables will be completed:

- Results from NetFlow analysis: NetFlow data for Internet2 will be analyzed with algorithm II. Algorithm III will be tested on Internet2 NetFlow data for delivery to Chris Tracy for ESnet NetFlow data analysis. Further statistical analysis will be conducted over the resulting data sets of alpha flows.

- OWAMP data analysis: We will begin the analysis of Internet2 OWAMP data obtained for a two-week period.

- OpenFlow experiments: We will begin experiments using the OpenFlow switches in the LIMAN testbed to obtain measurements for firewall filter configuration.

**Any changes in approach or aims and reasons for change. Remember significant changes to the objectives and scope require prior approval by the contracting officer.**

None.

**Actual or anticipated problems or delays and actions taken or planned to resolve them.**

None.

**Any absence or changes of key personnel or changes in consortium/teaming arrangement.**

None

**A description of any product produced or technology transfer activities accomplished during this reporting period, such as:**

**A. Publications (list journal name, volume, issue); conference papers; or other public releases of results.**

- Z. Yan, C. Tracy, M. Veeraraghavan, "A Hybrid Network Traffic Engineering System," accepted in IEEE HPSR 2012, June 24-27, 2012.
- J. Li, M. Veeraraghavan, "A Reliable Message Multicast Transport Protocol for Virtual Circuits," accepted in the 2012 4th International Conference on Communications, Mobility, and Computing (CMC 2012), 21-23 May 2012, pp. 119-123.
- Jie Li, Matthew Manley, Malathi Veeraraghavan, Steve Emmerson, "Analysis and selection of a network service for a scientific data distribution project," accepted in the 2012 4th International Conference on Communications, Mobility, and Computing (CMC 2012), 21-23 May 2012, pp. 124-127.
- Z. Yan, Z. Liu, C. Tracy, and M. Veeraraghavan, Hybrid network traffic engineering system (HNTES)," ESCC Meeting at Joint Techs Baton Rouge, LA Jan. 25-26, 2012.
- Z. Yan, Z. Liu, C. Tracy, and M. Veeraraghavan, "Hybrid Network Traffic Engineering System," Talk presented at Annual DOE PI meeting for the ASCR Network & Middleware, Mar. 1-2, 2012.
- Z. Liu, M. Veeraraghavan, Z. Yan, C. Tracy, J. Tie, I. Foster, J. Dennis, J. Hick, Y. Li and W. Yang, "On using virtual circuits for GridFTP transfers," submitted to SC 2012.

**B. Web site or other Internet sites that reflect the results of this project.**

- *UVA Hybrid Networking Project web site*: http://www.ece.virginia.edu/mv/research/DOE09/index.html
- *Collaboration web site* for project participants to post documents, discuss issues in an online forum, archive emails, etc. The password-protected site is: https://collab.itc.virginia.edu/portal/site/e121f110-7b37-4021-8ac1-4d61197c067a/page/d4fece61-b037-411e-9866-c8a890ee22c2

**C. Networks or collaborations fostered.**

We are working closely with the Chris Tracy, ESnet, and the ANI Tabletop Testbed design team, including Brian Tierney, Inder Monga, Chin Guok and Eric Pouyoul, ESNet.

**D. Technologies/Techniques.**

HNTES2.0 software modules, such as OFATv3, have been developed. They are currently under test. As noted earlier, the software will be made available via our open project web site.

**E. Inventions/Patent Applications**

None.

**F. Other products, such as data or databases, physical collections, audio or video, software or netware, models, educational aid or curricula, instruments or equipment.**

HNTES software, and results of traffic analysis, are available through our project web site.